Physics Lab – Virtual Ripple Tank

Setup: Use diagrams or describe what you see at each step.

a. Go to phet.colorado.edu/web-pages/simulations-base.html

b. Click on "Sound & Waves" on the left panel

c. Click on "Wave Interference"

Part I: Determine the speed of waves in water.

1. *Design Your Procedure* – What would you do to figure out the speed of waves in water? Describe the steps you would take and the virtual tools you would use to figure this out. You should have a clear, step-by-step description that anyone in the class would be able to follow. (No numbers in this section, just a description.)

2. *Collect Your Data* – What data did you collect using the procedure you created in #1? How many times did you collect data to be confident in your accuracy? The data should be clearly organized in a way that matches your procedure.

3. *Make Your Calculations* – What calculations do you need to make on the data you collected? Show the equations you use and your answer for the speed of waves in water. Pay attention to significant digits.

4. *Check Your Results* – "Doing good science" requires that a researcher's results can be independently checked by other researchers. Compare your answer for the speed of waves in water with that of a classmate and record both numbers.

   Why might your numbers be different?

   Should everyone get the same number or is it okay to have different numbers?

   What is the percentage difference between your numbers? Is it "significant"?

(continued on back)

Part II: Investigate ripple patterns.

5. *Play With The Ripple Tank* – Observe the different ripple patterns you get with changes to the waves and the ripple tank. Describe or draw diagrams: For example:

   See what happens with one faucet vs two faucets.

   Turn the faucets on and off.

   Change the frequency and amplitude of the drops.

   Add a barrier with one slit or two slits and move the barrier left and right.

   Change the width and spacing of the slits in the barrier.

6. *Create An Interesting Ripple Pattern* –

   Set the frequency near the middle of the scale.

   Set the amplitude near the right end (the high end) of the scale.

   Add a barrier and put it at 6.2 cm (check the "Barrier Location" scale).

   Set the slit width to 2.5 cm or higher.

   You may choose the other variables as you like – one faucet or two, one slit or two, any faucet spacing, any slit separation, etc. But be careful, because the next step is…

7. *Draw Your Ripple Pattern* – Pause the ripple tank. Using a colored pencil for the crests and a dark pencil for the troughs, draw the ripple pattern. Pay attention to where the colors are brightest and where they are dim.

Part III: Identify wave behaviors: Use your diagram above to do the following.

8. *Reflection* – Circle an area of your diagram that shows wave reflection and label this area "reflection".

9. *Diffraction* – Circle an area of your diagram that shows wave diffraction and label this area "diffraction". Below the diagram, describe what "diffraction" means.

10. *Constructive Interference* – Mark a point on your diagram that is an example of constructive interference. Below the diagram, describe what "constructive interference" means.

11. *Destructive Interference* – Mark a point on your diagram that is an example of destructive interference. Below the diagram, describe what "destructive interference" means.

Bonus: What's Out There?

12. Describe what is just beyond the right-hand side of the ripple tank and support your hypothesis.

Introduction to Fourier Analysis

Learning Goal: To gain a qualitative intuitive understanding of Fourier Analysis

Open the simulation “Fourier: Making Waves” from the Math Tools section of the PhET simulations website.

Try playing with the controls on the “Amplitudes” graph. (Checking the “autoscale” box next to the “Sum” graph may make it easier to see what’s going on.) How does changing the “Amplitudes” graph change the “Harmonics” and “Sum” graph? Explain how these three graphs are related.

Hit the “Reset” button so that there is only one sine wave shown.

What is the definition of wavelength?

Use the horizontal zoom controls next to the “Harmonics” graph so that more than one period is displayed on the graph. Check the “Wavelength Tool” box and use the tool that appears to measure from peak to peak, from trough to trough, and then from some arbitrary point in the wave to the same arbitrary point on cycle farther. Is this consistent with your definition of wavelength?

Adjust the amplitudes to show more than one sine wave, and use the pull-down menu for the wavelength tool to compare the wavelengths of different sine waves.

In general, does amplitude depend on wavelength?

Does changing the amplitude of a wave change its wavelength?

Try switching from a function of space to a function of time. What changes? What doesn’t change?

Explain why you can’t use the Period Tool in “space” mode or the Wavelength Tool in “time” mode.

How are the periods of different harmonics related?

Is this consistent with a definition of “harmonics” that you have heard in the context of sound and music?

What happens when you switch from showing “sines” to “cosines”?

Try out the different options in the "Select Function" pull-down menu. For each function, try increasing and decreasing the number of harmonics. What effect does this have and why?

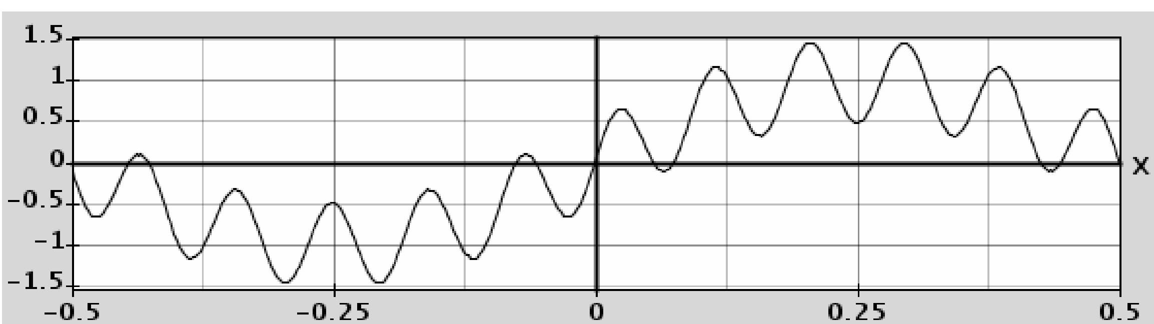
What would happen if you had many more than 11 harmonics?

Test your prediction by checking the box labeled, "Show function with infinite number of harmonics."

Explain in words why each harmonic should have the approximate amplitude that it does in order to make up a triangle wave. For example, why are all the even harmonics zero? Why is the third harmonic negative or positive? Are the amplitudes different for sines and cosines? Why?

What happens if you try to make a sawtooth wave in "cosines" mode? Why?

Which harmonics would you need to include to produce the following "Sum" graph?



Learning

Waves on A String

Directions:

1. Open *Waves on a String,* **investigate** wave behavior using the simulation for a <u>few</u> minutes. As you look at the waves' behavior, **talk** about some reasons the waves might act the way they do.

2. **Write** a list of characteristics that you will use in this activity to describe the waves. **Describe** each characteristic in words that any person could understand. Leave some writing space for characteristics that you might think of later during the activity.

3. With the *Oscillate* button on and with *No End* checked, **investigate** waves more carefully using the *Amplitude* slider. **Write** answers to the following after your group has talked about each and agreed.

   a) Define *Amplitude* in everyday language.

   b) Explain how the wave behaves as the *Amplitude* changes using the characteristics you described in #2

   c) Use a rope on the floor for some investigations and explain how you could change the *Amplitude* of a wave.

4. Repeat step number 3, for *Frequency, Tension* and *Damping*.

5. Set *Amplitude* on high, *Frequency*, *Damping* and *Tension* on low. Also, have on *Oscillate*, *Timer* and *No End*. Use the *Pause* button to freeze the wave.

   a) **Place** a blank piece of paper on your monitor and **trace** the wave and the wave generator. **Mark** the green balls. This is a <u>vertical position- horizontal position </u>graph, label your axes.

   b) Quickly press *Play,* and then *Pause* again. Use the same piece of paper, put it on the monitor and make sure to get the generator in the same spot. **Trace** the new wave.

c) **Write** about the differences and similarities in the characteristics. You may have to do some more tests by pressing *Play,* then *Pause* and tracing to test your ideas.

d) Try some other settings and **talk** about why I recommended the settings that I did.

6. Set *Amplitude* on high, *Frequency*, *Damping* and *Tension* on low. Also, have on *Oscillate*, *Timer* and *No End*. Use the *Pause* button to freeze the wave.

a) **Measure** the vertical location of a green ball with a ruler.

b) **Record** the vertical position and time.

c) Quickly press *Play,* then *Pause* repeatedly to **make** a data table the vertical position of the green ball versus time.

d) **Make** a graph of vertical position versus time.

e) **Write** about the differences and similarities between vertical position- horizontal position graphs and vertical position-time graphs.

7. **Investigate** how waves behave when the string end is *Fixed* and *Loose* with *Manual* settings. **Discuss** the behavior with your partners. **Test** your ideas and the **write** a summary.

8. **Read** in your book to find out what a standing wave is, **investigate** how to produce one with the simulation and **write** a procedure that another student could follow to produce a standing wave.

Fourier-Making Waves Activity 1: Wave Representation

You will need your Waves on a String answers to do this activity.

Learning Goals:

Students will be able to think about waves as a function of time, space or space-time and explain why waves might be represented in these different ways.

1. Discuss with your partner how you usually think about waves. Make drawings to help you explain the images in your mind as you try to explain waves.

2. Open *Fourier-Making Waves.* Investigate how changing amplitude affects the wave. How do your findings compare to your findings from number 3 in the *Waves on a String* activity? Describe in your own words what the y-axis for wave graphs represents.

3. Change the *function of* to *time(x).* Record how the waves compare, the axes labels and which tools change. Then, repeat using *function of time and space*.

4. Which representation does *Waves on a String* use? (you may need to open *Waves on a String* again)

5. In number 5 in the *Waves on a String* activity, the graph you made was called <u>vertical position-horizontal position</u> graph. Summarize how you made the graph. What would you have to do in *Fourier-Making Waves* to make a similar graph?

6. In number 6 in the *Waves on a String* activity, the graph you made was called <u>vertical position-time</u> graph. Summarize how you made the graph. What would you have to do in *Fourier-Making Waves* to make a similar graph?

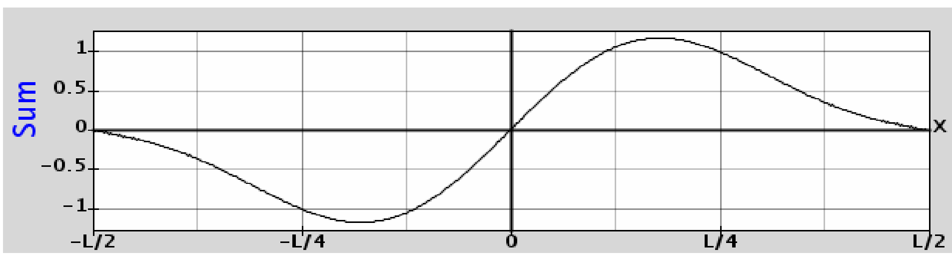
Students will be able to:

- Define harmonic, determine the relationship between the harmonics,
- Explain the relationship between harmonics and the corresponding wave function.
- Predict what happens when more than one wave is present.

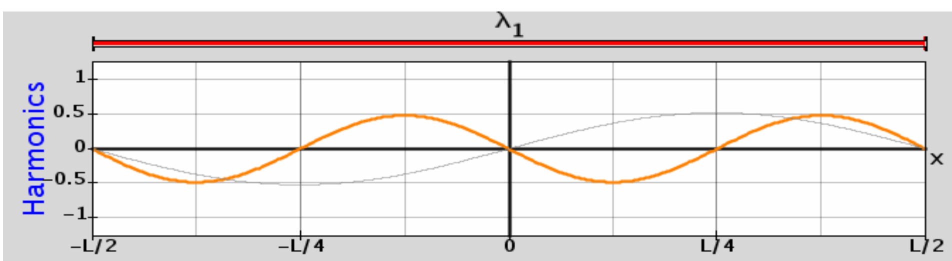
1. Investigate what harmonics are and describe in your own words what harmonic means to you. (You can use the *Wavelength* tool to determine a mathematical relationship between harmonics)

2. Investigate Functions using the *Select Function* tool and *Harmonics* slider. Describe the findings of your investigation.

3. Use the simulation to make a *Sum Graph* that looks like the graph below using only 2 harmonics. It's important to match both the x and y axes. Draw your *Harmonics Graph,* record the Amplitudes that you used, and describe what you thought about as you tried to match the graph.

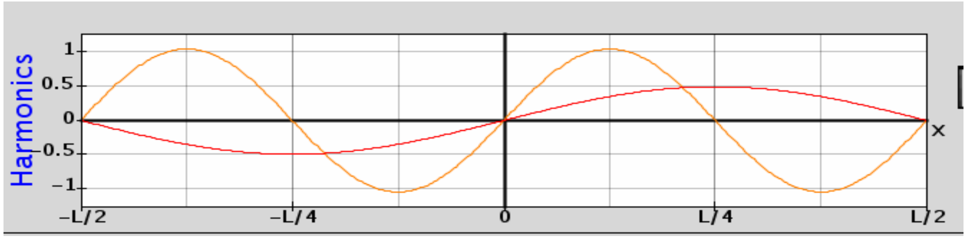


4. Use your thoughts from the previous questions to draw what you think the Sum Graph will look like for the harmonics displayed below.



Use the simulation to test your prediction and make corrections with a different color pen. Record the amplitudes that you used and write a plan for how you could predict the sum of waves.

5. Use your predictions ideas to draw the sum of these waves.



Test your ideas using the simulation. Make corrections on the predicted graph with a different color pen. Correct your plans for prediction also.

6. Design a test for your ideas on wave addition. Explain in detail your experiment and the results. Include evidence that your prediction method is repeatable.